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(71) Applicant: SARDON INTERNATIONAL LIMITED
28, Wylde Green Road
Sutton Coldfield West Midlands B72 1HD(GB)

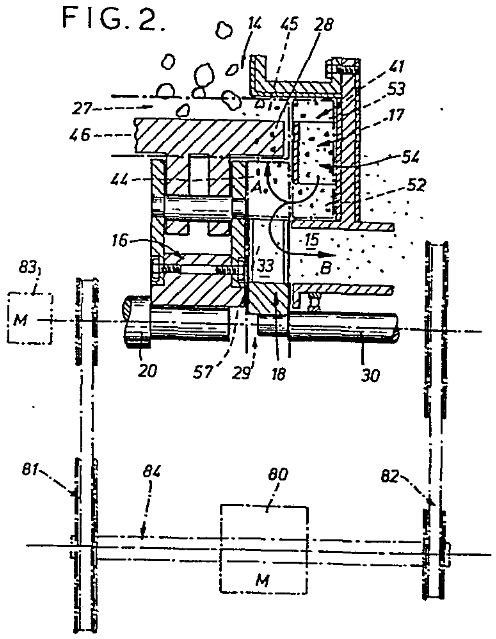
(72) Inventor: Rowledge, Bernard John
Wylde Green Road
Sutton Coldfield West Midlands B72 1HD(GB)

(74) Representative: Yelland, William Alan et al,
H.N. & W.S. SKERRETT Rutland House 148, Edmund Street
Birmingham B3 2LQ(GB)

(54) **Pulveriser machines.**

(57) A pulverising machine in which alongside the pulveriser rotor 16 are a classifier zone 29 and a conveyor zone 41. The rotor 16 has pulveriser members 25 which project into an annular reducing zone 27. Guide means 17 is provided in the conveyor zone to provide spiral paths to convey a rotating flow of air and reduced material spirally inwards from one end part 45 of the reducing zone to the classifier zone 29, and the latter is positioned to allow oversize material particles to pass outwards from the classifier zone direct to said end part of the reducing zone whilst the undersize particles are carried inwards, optionally *via* a rotary classifier 18, to an outlet 15.

FIG. 2.



EP 0 051 389 A2

This invention concerns a pulverising machine comprising a housing defining a chamber provided with an air inlet and an outlet, means to admit material into the chamber, a pulveriser rotor rotatable within the chamber about an axis and provided with a plurality of pulveriser members which project into an annular reducing zone of said chamber, and classifier means disposed in said chamber between said reducing zone and said outlet.

In known pulverising machines the classifier means comprises a rotary classifier, and the machines are arranged so that a flow of air and particulate material is conveyed from the reducing zone to the rotary classifier, from which rotary classifier oversize particles of the material are returned to the rotor for further reduction.

In some of these pulverising machines, for example the machines described in British Patent Specification No: 1333044, the pulveriser rotor and the housing provide spaced apart surfaces between which surfaces the air and particulate material flow passes in a direction towards the classifier and the oversize particles pass through this flow against the direction of flow, which gives rise to certain disadvantages where considerable quantities of oversize particles are being returned due to the latter impeding the flow. For example, the machines need a very considerable air supply to maintain the flow, and have a consequential high power consumption.

These disadvantages are reduced in other known forms of the pulverising machines, which machines are arranged to provide a return path for the oversize particles to return to the rotor without passing completely through said flow to the classifier. However, the known return paths return the oversize particles to mix with the un-reduced material fed to the rotor by a feed means so that the returned oversize particles undergo the substantially same reduction processes as the un-reduced material, for example, as indicated in Figures 8-50 of the "Chemical Engineers Handbook" published in 1973 in the U.S.A. by McGraw-Hill Inc. Such pulverising machines thus produce large amounts of particles which are reduced to a much smaller size than the maximum size acceptable, i.e. excessive reduction arises, with a consequential heavy power consumption.

In other known forms, for example, the Mikro-ACM Pulveriser shown in Figures 8-51 of the "Chemical Engineers Handbook" published in 1973 in the U.S.A. by McGraw-Hill Inc., a shroud is provided between part of the flow path to the rotary classifier and the return path; but to enable the air flow to move the particulate material inwards towards the axis of the rotary classifier, for classification, baffles have to be provided in said part of the flow path to ensure that the flow has little or no rotational momentum, with the result that substantially the whole of the material in the flow must enter and be accelerated rotationally by the classifier and the oversize particles ejected from the classifier against the flow direction, if the passage of unclassified material to the return path is to be prevented. This arrangement gives rise to other disadvantages. For example it imposes considerable demands on the design, operation and power supplies of the classifier, with a consequential heavy power consumption.

An object of the invention is to enable the power consumption to be reduced or utilised more efficiently whilst enabling the aforementioned disadvantages to be avoided or reduced.

According to the present invention there is provided a pulverising machine which is characterised in that:

(a) the classifier means comprises a classifier zone alongside the pulveriser rotor;

(b) a conveyor zone of annular form is provided in said chamber, which conveyor zone has an outer portion alongside one end of the reducing zone and an inner end portion alongside the classifier zone;

(c) at least one of said pulveriser members has an extension which extends in said reducing zone across the periphery of the classifier zone to adjacent said conveyor zone; and

(d) the machine is provided with guide means which includes guide members extending within the conveyor zone to define therein a plurality of part spiral conveyor paths to convey a flow spirally inwards from said outer part to said inner part.

In use, air is supplied so as to flow through the apparatus from the inlet to the outlet and material, fed into the chamber, is reduced in the reducing zone by the pulveriser rotor and mixes with the air flowing in the chamber. The rotor imparts a rotational velocity to the flow of air and material in the reducing zone, and causes the rotating flow to move, in a first direction parallel to the axis, across the reducing zone to the outer part of the conveyor zone. In the conveyor zone the flow enters the conveyor paths to move inwards to the inner part, and therafter moves from the inner part to the classifier zone, whilst maintaining a large proportion of the kinetic energy of the flow.

The maintaining of the kinetic energy permits much of the rotational momentum of the material to be conserved, so that centrifugal forces tend to cause the material to move outwards along a return path from the classifier zone direct to the reducing zone so as to pass said extension or extensions. The reduced material can thus be subjected to a substantial degree of classification in the absence of any rotary classifier.

Furthermore, a partition is preferably provided between said extensions and the guide means so that the return path is quite separate from the conveyor paths due to the partition therebetween, thus avoiding the known problems caused by particles of material or flows moving in opposite directions. The return path leads to a final portion of the reducing zone immediately adjacent the conveyor zone so that the returned particles only undergo a much shorter period of further reduction, and thus the problems caused by interference of the returned particles with the initial reduction of the material are reduced and the production of undersized particles is minimised. The invention provides further advantages. For example, the passage of the flow of air and material through the plurality of conveyor paths causes a slowing of the faster moving particles due to collisions with the slower moving particles, and causes the speed of latter to be increased, thus making the particle velocities more uniform and improving the effectiveness of the classification.

The guide members may be of part spiral or part chordal form, and may be movable or adjustable to vary the effect of the guide means upon said flow, e.g. to modify the classification.

The classifier means preferably further includes a rotary classifier which is rotatable within the classifier zone to provide further or improved classification, which rotary classifier may be provided with variable speed drive means or connected by variable speed transmission means to means for driving the pulveriser rotor and may be confined to an inner portion of the classifier zone or may extend into or across the part of the classifier zone alongside the inner part of the conveyor zone.

The extensions serve also as impeller members which tend to create or drive a flow of air along the return path, and the machine may incorporate rotary attenuator means to reduce this impeller effect. The attentuator means may be incorporated into the rotary classifier or may be substituted in place of the rotary classifier. The attenuator means may likewise have a variable speed drive means or variable speed transmission means connected to means for driving the pulveriser rotor.

The means to admit material to the chamber preferably comprises an opening at the periphery of a main portion of the reducing zone which main portion is disposed alongside the final portion. The air inlet may be arranged so as to be tangential to the rotor and immediately before (in the direction of rotor rotation) of the opening. This arrangement of the air inlet and opening causes the air flow to apply a thrust to the material in the direction of rotation. A further or alternative air inlet may be provided to supply an air flow in a direction towards the side of the rotor remote from the conveyor zone to apply a thrust in said first direction parallel to said axis.

The pulveriser rotor and the rotary classifier are preferably operatively connected to the same drive motor.

The invention will be described further, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 shows a vertical section, of a grinding machine of the invention, in a plane including the axis of a pulveriser rotor of the machine;

Figure 2 is a diagram showing parts of zones of a chamber defined within the machine and drive means for the machine;

Figures 3, 4 and 5 are sections through the machine, normal to said axis, showing, respectively, the pulveriser rotor, a classifier, and guide means of the machine, with some parts omitted for clarity;

Figure 6 shows a modified form of the grinding machine in vertical section;

Figures 7 and 8 are sections similar to Figures 4 and 5, of the modified machine shown in Figure 6.

Both forms of the pulverising machine comprises a housing 10 which defines a chamber 11, and is provided with a main air inlet 12, a secondary air inlet 13, a material inlet 14 and an outlet 15. Within the chamber 11 are a pulveriser rotor 16, guide means 17 and a rotary classifier 18. The chamber is substantially cylindrical about an axis 19 of a rotor drive shaft 20 which is mounted on bearings 21 so as to project into the chamber through one side wall of the casing.

The pulveriser rotor 16 comprises a hub 22 carrying a pair of parallel circular side plates 23 which support a circular array of bearing pins 24, each of which carries a swingable pulveriser member 25 having an outer portion 26 which projects radially from the periphery of the rotor so as to be disposed in an annular reducing zone 27 of the chamber, which zone 27 is indicated in broken lines in Figure 2.

Each outer portion 26 has an extension 28 which projects from one side of the rotor 16, in a direction parallel to the axis, across the periphery of a classifier zone 29 of the chamber, which zone 29 is approximately cylindrical as indicated in broken lines in Figure 2.

The rotary classifier 18 is disposed within the classifier zone 29 (indicated in broken lines in Figure 2), so as to be closely adjacent said one side of the rotor 16, and is carried by a second shaft 30, co-axial with said axis 19, which shaft 30 is carried by bearings 31 carried by a support 32 which projects within the outlet 15 to adjacent the rotary classifier.

The housing 10 includes an annular wall 40 co-axial with the axis, which wall 40 surrounds the outlet and extends into the chamber to terminate at one side of the classifier zone. The wall 40 also serves an inner boundary of an annular conveyor zone 41 indicated in broken lines in Figure 2, which zone 41 extends outwards to a peripheral wall 42 of the housing so as to be disposed between a second side wall 43 of the casing and adjacent portions of the reducing and classifier zones. These adjacent portions comprise an outer portion 44 (Figure 2) of the classifier zone and a final portion 45 (Figure 2) of the reducing zone.

The guide means 17 comprises a ring member 50 which is disc shaped, and several guide members 51, and is disposed across an intermediate portion of the conveyor zone 41, which intermediate portion is disposed between an inner portion 52 (Figure 2) and an outer portion 53 (Figure 2) of the conveyor zone.

The ring member 50 serves as a partition between the intermediate portion and said adjacent portions 44 and 45. The guide members 51 extend from said partition to the wall 43 and are shaped to define part spiral conveyor paths 54 Figures 5 and 8 which extend from said outer portion 53 to said inner portion 52.

The extensions 28 lie in and are outwardly surrounded by the final portion 45, which final portion extends from a main portion 46 (Figure 2) of the reducing zone, and the remainder of each outer portion 26 is disposed in and is outwardly surrounded by the main portion 46.

The material inlet 14 is disposed at the top of the peripheral wall 42 and is radial to said axis so as to permit material, fed to the inlet by feed means (not shown), to fall towards the rotor through the main portion 46. The main air inlet 12 is disposed adjacent to the material inlet 14, and ahead of the inlet 14 in the direction of rotation (arrow 47 in Figure 3) of the rotor, and is inclined so as to direct the flow of air in a direction tangential to the rotor and directly across the path of the material entering the reducing zone. The secondary air inlet 13 is disposed in said one side wall of the housing 10 so as to direct a flow of air through the reducing zone and across the rotor towards the conveyor zone. A bottom opening 48 is provided in the peripheral wall 42 to allow foreign bodies to fall into a trap 49 below the chamber. The trap has an external door or hatch, not shown.

Thus, relative to the axial direction, there is the main portion 46 of the reducing zone 27; followed by the classifier zone 29 surrounded peripherally by the final portion 45 of the reducing zone, which are axially offset from the main portion 46; and finally the conveyor zone 41 which is disposed around the outlet 15 and is further axially offset from the main portion 46.

The walls of the chamber have a hard wearing internal skin 55 which is preferably ridged at least around the reducing zone to provide projections 56 transverse to the direction of rotation.

In the form shown in Figure 1, the rotary classifier 18 comprises several vanes or blades 33, of channel shaped cross-section, which project from a hub 38 on the shaft 30. The vanes or blades 33 are curved to part spiral form so that the outer ends 34 lag the inner ends 35 in the direction of rotation of the classifier, which direction is indicated by the arrow 37 in Figure 4; and are located so that the walls 36 of the channels project in the direction of rotation.

In the form shown in Figure 6, the rotary classifier 18 comprises short radially disposed vanes 133 which are carried by a circular plate 60 secured to the hub 38. These vanes 133 are radially short and terminate at a radius equal to that of the wall 40, and are braced by a ring plate 61 which overlaps the wall 40, which wall 40 is shortened to allow the axial length of the vanes 133 to be increased.

In both forms the rotary classifier 18 incorporates rotary attenuator means 70. In the form shown in Figure 1 the outer ends 34 of the classifier vanes or blades 33 constitute the attenuator means 70 which is thus integrally incorporated in the rotary classifier: whereas in the form shown in Figure 6 the circular plate 60 carries radial arms 62 having outer ends 134 which constitute the attenuator means 70.

In use, the material is reduced by the pulveriser members 25 in the main portion 46, and a rotating flow of particulate material and air is produced, which flow moves progressively across the main portion 46 and across the final portion 45 so as to enter the outer portion 44 whilst still rotating at a considerable velocity. The flow then enters the conveyor paths 54 and is carried by its momentum and the thrust of the air flow spirally inwards to the inner portion of the conveyor zone with minimal energy loss. As mentioned hereinbefore the particle velocities are made more uniform, by mutual collisions, during transit through the paths. The flow then moves, whilst still rotating, back towards the rotor to enter the outer portion 44 of the classifier zone. Irrespective of the presence or absence of, and the diameter and speed of rotation of, the rotary classifier, the larger particles of the material will follow a return path indicated by arrow A outwards through the outer portion 44 and back into the final portion 45, due to the centrifugal forces acting on said particles; whereas the smaller particles (having a greater surface area to mass ratio) will be conveyed by the air flow inwards to an inner portion 57 of the classifier zone and then to the outlet 15, along a discharge path indicated by arrow B, so that said classifier zone serves as classifier means which utilises particle momentum to effect classification.

In the absence of the rotary classifier there will be a substantial amount of particles of intermediate sizes which can follow either of the paths A and B depending on the particle velocities and the position, relative to the axis, of entry into the classifier zone. Clearly this amount can be reduced by means of the rotary classifier to reduce the threshold of the size admitted to the outlet 15, which threshold can be varied by varying the speed of rotation or changing the rotary classifier for one of different size or vane structure, e.g. the vanes 33 can project to any degree across the side of the inner portion 52, or may merely project across the side of the outlet 15 as indicated in Figure 2.

The flow in the machine will create a pressure differential between the portions 53 and 52 tending to cause a flow from the final portion 45 to the portion 44 by-passing the conveyor zone: whereas the extensions 28 act collectively as an impeller to tend to draw a rotating current of air outwards, from the outer portion 44 of the classifier zone to the final portion 45 of the reducing zone 27. In the absence of any attenuator means (e.g. as shown in Figure 2) the nett result will, in most cases, be an appreciable outward movement of the rotating current of air. However, the impeller effect is reduced by the attenuator means if the latter rotates at a lesser speed than the rotational speed of the pulveriser rotor 16. The preferred range of speed of the shaft 30 is between 20% and 50% of the speed of the shaft 20.

The impeller effect upon rotating current can also be reduced by providing radial fins 71 upon the partition as indicated in Figure 6, and by increasing the spacing between the extensions and the partition, at the expense of increasing the by-pass effect.

It will be readily appreciated that the foregoing embodiment will provide the advantages, and avoid the disadvantages mentioned hereinbefore, and is adapted to be constructed in an economical manner, e.g. mainly from steel plate, so as to avoid expensive investment in castings and to enable the dimensions of the machines to be selected or varied to suit particular needs without requiring a range of casting patterns. Furthermore, the machine is constructed so as to facilitate repair and modification, e.g. the side 43 (together with the rotary classifier, outlet and a discharge duct 66) is detachable from the rest of the casing to provide access to the guide means, classifier and rotor; and the rotor is assembled so that one or both of the side plates 23 can be detached to release the pins 24 and members 25.

Because only part of the reduction of the material fed to the chamber is performed by the extensions 28, and because all the further reduction of the particles, which have returned, via the return path, is performed by the extensions 28, the amount of further reduction can be reduced by reducing the projection of or the number of said extensions without reducing the amount of reduction of the material which takes place in the main portion 46 of the reducing zone.

Furthermore, the machine does not "choke" i.e. become blocked, when fractionally overloaded or worked continuously at maximum capacity.

Whilst the pulveriser rotor and the rotary classifier may be connected to separate drive and speed control units, the machine of the invention provides the further advantage that the energy of the flow in the machine is maintained to such a degree that it can drive the rotary classifier and/or the rotary attenuator if the latter is or are arranged to rotate more slowly than the pulveriser rotor, and power can be taken off the shaft 30. For example, a drive motor 80 can be connected by a first belt and pulley transmission system 81 to the shaft 20 and by a second belt and pulley transmission system 82, preferably of variable speed form, to the shaft 30 to return power to the shaft 20 via the motor. Alternatively if a drive motor 83 in line with the shaft 20 is used, a lay shaft 84 may connect the transmission systems, as indicated in Figure 2.

The invention is not confined to the details of the foregoing examples and many variations are possible within the scope of the invention. For example, the guide means may be movable, may comprise adjustable guide members and means to adjust the guide members or means, may have guide members formed from steel plate, and each guide member may be constituted by a plurality of elements, and shaped members may be provided to smooth the path of the flow at the entrance to and the exit from the guide means.

The rotor shaft may also carry the classifier for common rotation. Either or both of the air inlets may be provided. The or some of the pulveriser members may be fixed rigidly to the rotor. The size, shape, and form of the partition may be varied, e.g. to constrict the return path so that it narrows in the outwards direction, or to broaden the conveyor paths to compensate for any reduction in width, to give constant flow cross-sectional areas along the paths. Furthermore, the ring member may be omitted. The guide members may be flanged to provide an array of flanges between the extensions 28 and the conveyor paths, which array serves as a substantially continuous or interrupted partition.

The air flow generated by the extensions 28, acting collectively as an impeller, can be adjusted by the attenuator means 70, thereby adjusting the flow through the conveyor zone 41, and in turn adjusting the speed of rotation of the flow emanating from the guide means 17. In this manner the centrifugal forces tending to reject oversize particles through the return path A to the final portion 45 may be altered and the threshold of particle size admitted to the outlet 15 adjusted independently of the rotary classifier or even in the absence of a rotary classifier.

It is preferable that by-pass forces generated by the air flow through the machine are substantially equal to or somewhat greater than the impeller forces generated by the outer portion's extensions 28 and prevent a nett outward air movement through the return path, so as to minimise recycling of very small particles.

To this end, and to provide fine control of the classification, the rotary attenuator may be mounted on a shaft concentric with the rotary classifier shaft for independent rotation.

The classifier or attenuator may be driven by a shaft passing through the rotor shaft.

The apparatus may be supplied with gas, gaseous medium, or a mixture thereof with air instead of an air supply. The air may be supplied under pressure, or the flow may be drawn from the duct 66 to induce the flow into the air inlet.

CLAIMS

1. A pulverising machine comprising a housing 10 defining a chamber 11 provided with an air inlet 12, 13 and an outlet 15, means 14 to admit material into the chamber, a pulveriser rotor 16 rotatable within the chamber about an axis 19 and provided with a plurality of pulveriser members 25 which project into an annular reducing zone 27 of said chamber, and classifier means disposed in said chamber between said reducing zone and said outlet; characterised in that:

(a) the classifier means comprises a classifier zone 29 alongside the pulveriser rotor 16;

(b) a conveyor zone 41 of annular form is provided in said chamber 11, which conveyor zone has an outer portion 53 alongside one end of the reducing zone 27 and an inner end portion 52 alongside the classifier zone 29;

(c) at least one of said pulveriser members has an extension 28 which extends in said reducing zone 27 across the periphery of the classifier zone 29 to adjacent to said conveyor zone 41; and

(d) the machine is provided with guide means 17 which includes guide members 51 extending within the conveyor zone 41 to define therein a plurality of part spiral conveyor paths 54 to convey a flow spirally inwards from said outer part 53 to said inner part 52.

2. A pulverising machine as claimed in Claim 1, wherein a partition 50 is provided between said pulveriser members 25 and said conveyor passages 54.

3. A pulverising machine as claimed in Claim 1 or 2, wherein the guide members are of part chordal form.

4. A pulverising machine as claimed in Claim 1, 2 or 3, wherein the classifier means further comprises a rotary classifier 18.

5. A pulverising machine as claimed in Claim 4, wherein the rotary classifier 18 is connected by variable speed transmission means 82 to means 80, 81 or 83 for driving the pulveriser rotor 16.

6. A pulverising machine as claimed in Claim 4 or 5, wherein the rotary classifier 18 incorporates rotary attenuator means 70.

7. A pulverising machine as claimed in Claim 4, 5 or 6, wherein the rotary classifier 18 is confined to an inner portion 57 of the classifier zone 29.

8. A pulverising machine as claimed in Claim 1, 2 or 3, wherein rotary attenuator means 70 is provided in said classifier zone 29.

9. A pulverising machine as claimed in Claim 8, wherein the rotary attenuator means 70 is connected by variable speed transmission means 82 to means 80, 81 or 83 for driving the pulverising rotor 16.

FIG. 1.

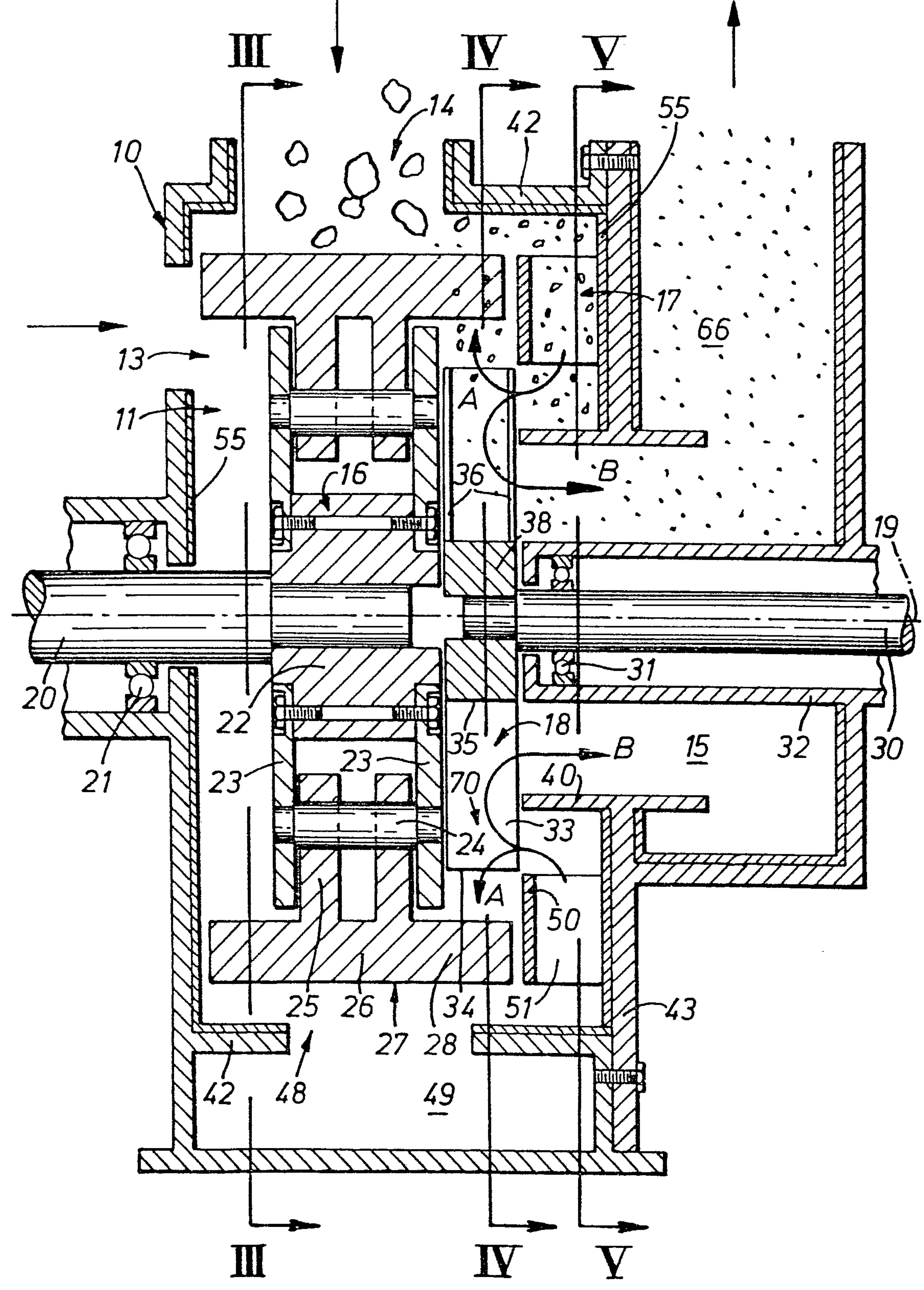

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FIG. 2.

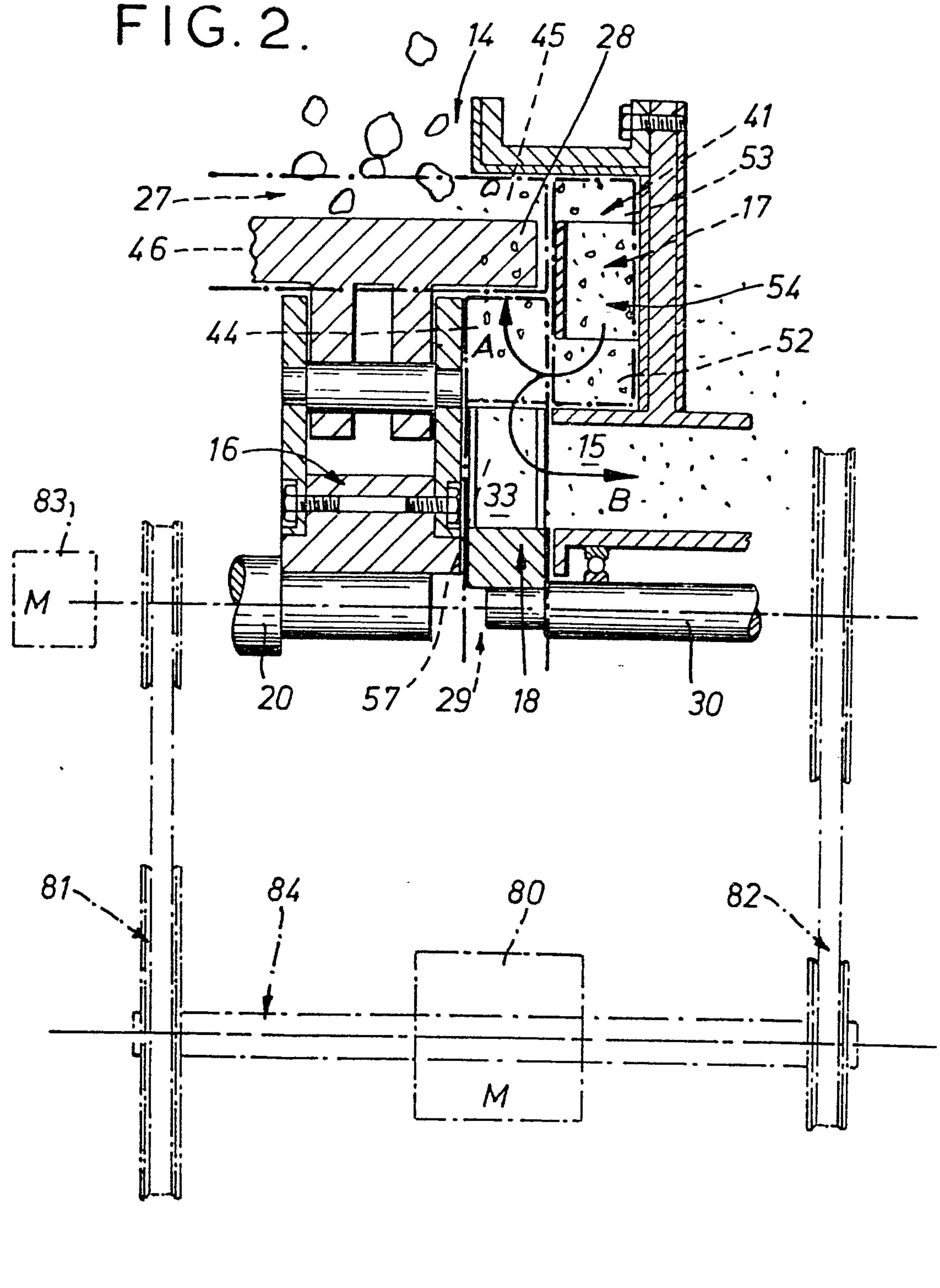
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FIG. 3.

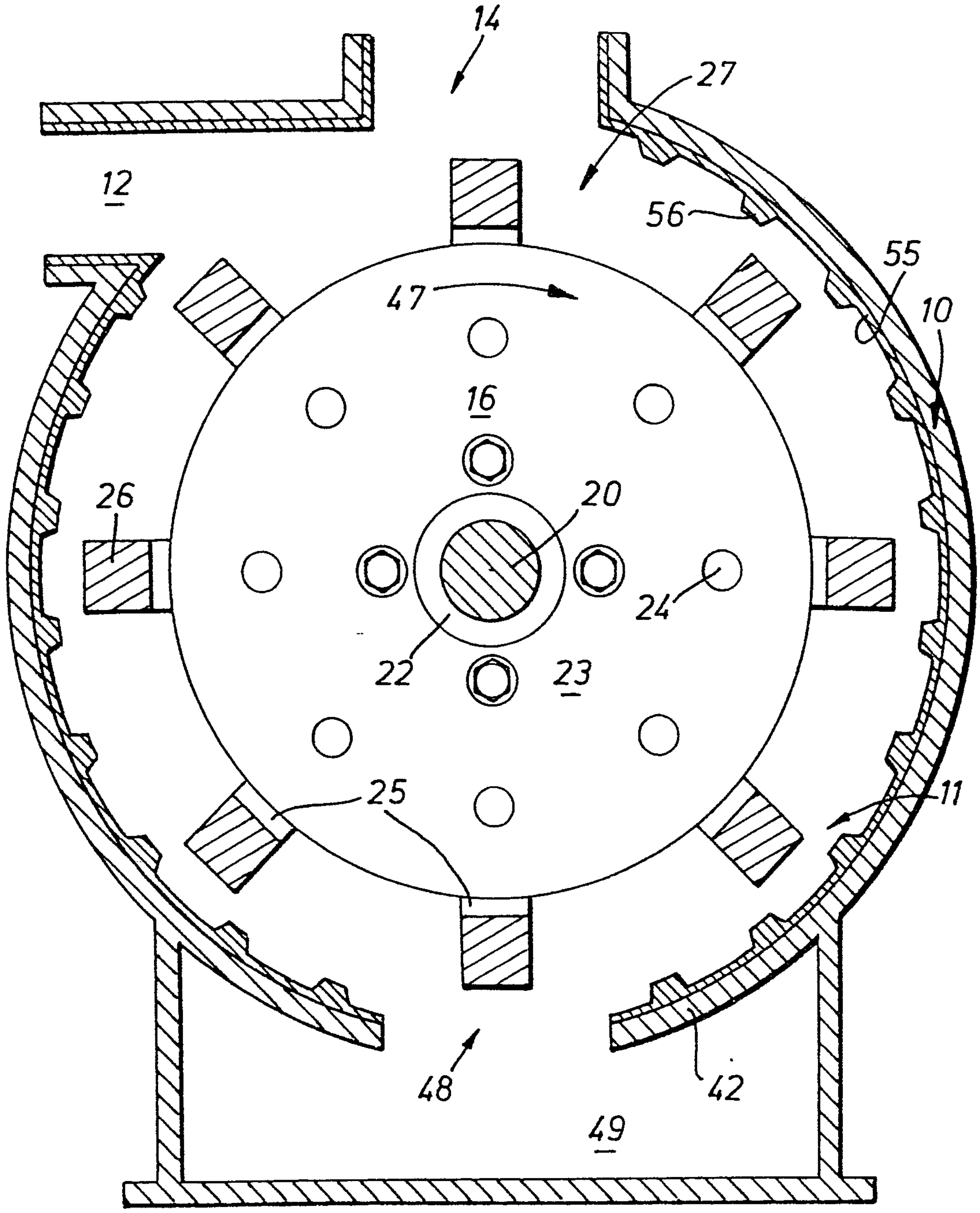

FIG. 4.

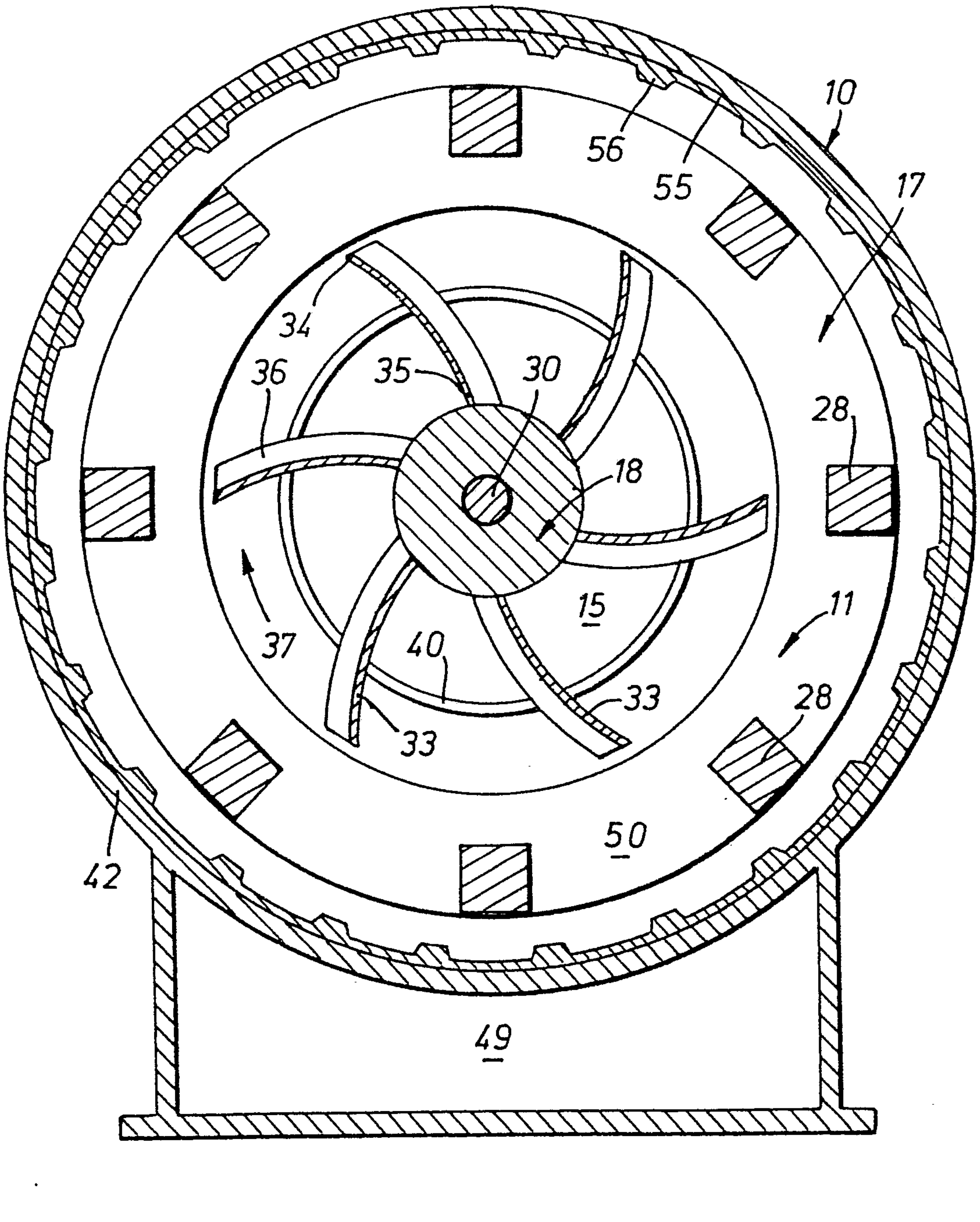

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FIG. 5.

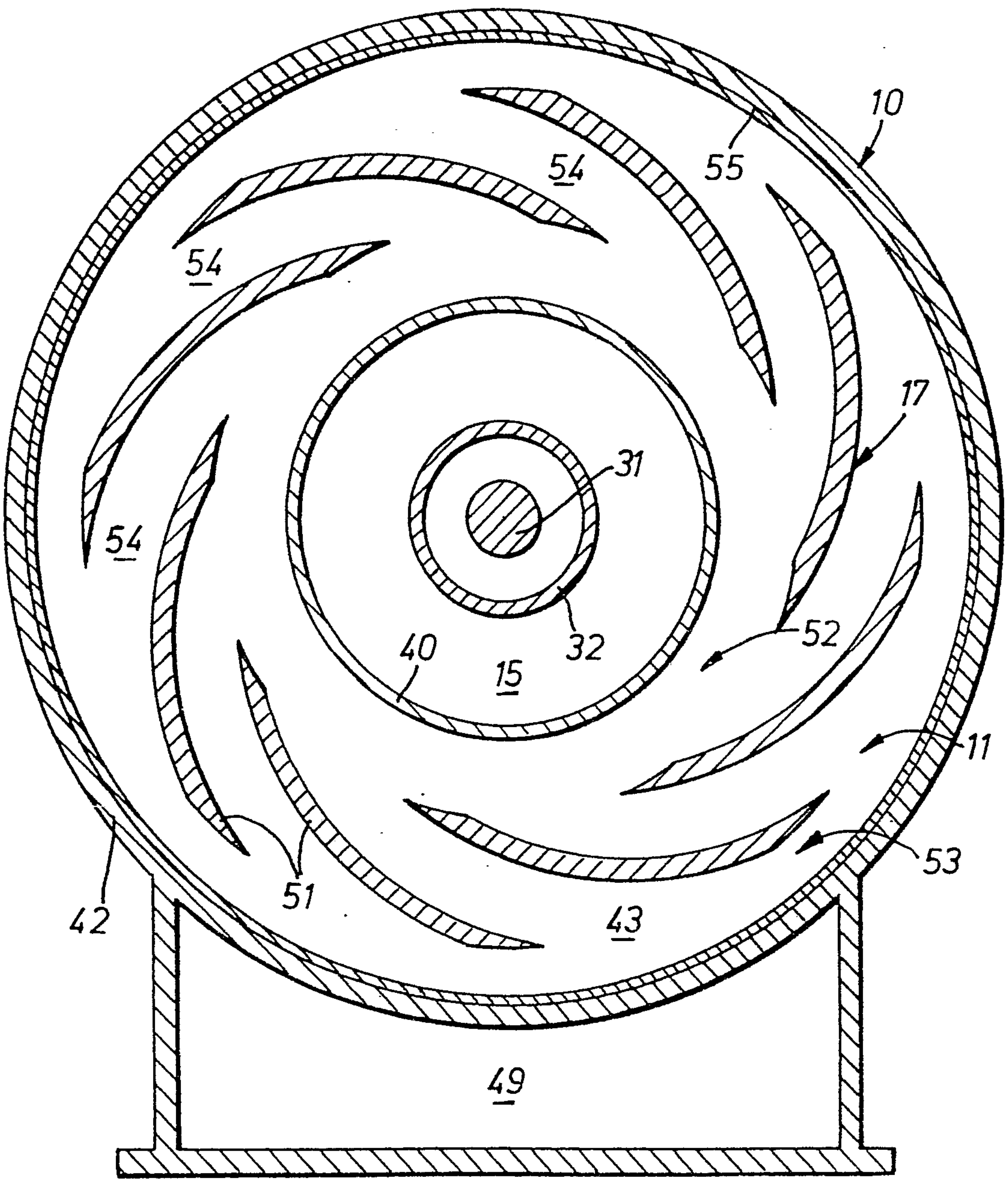

FIG. 6.

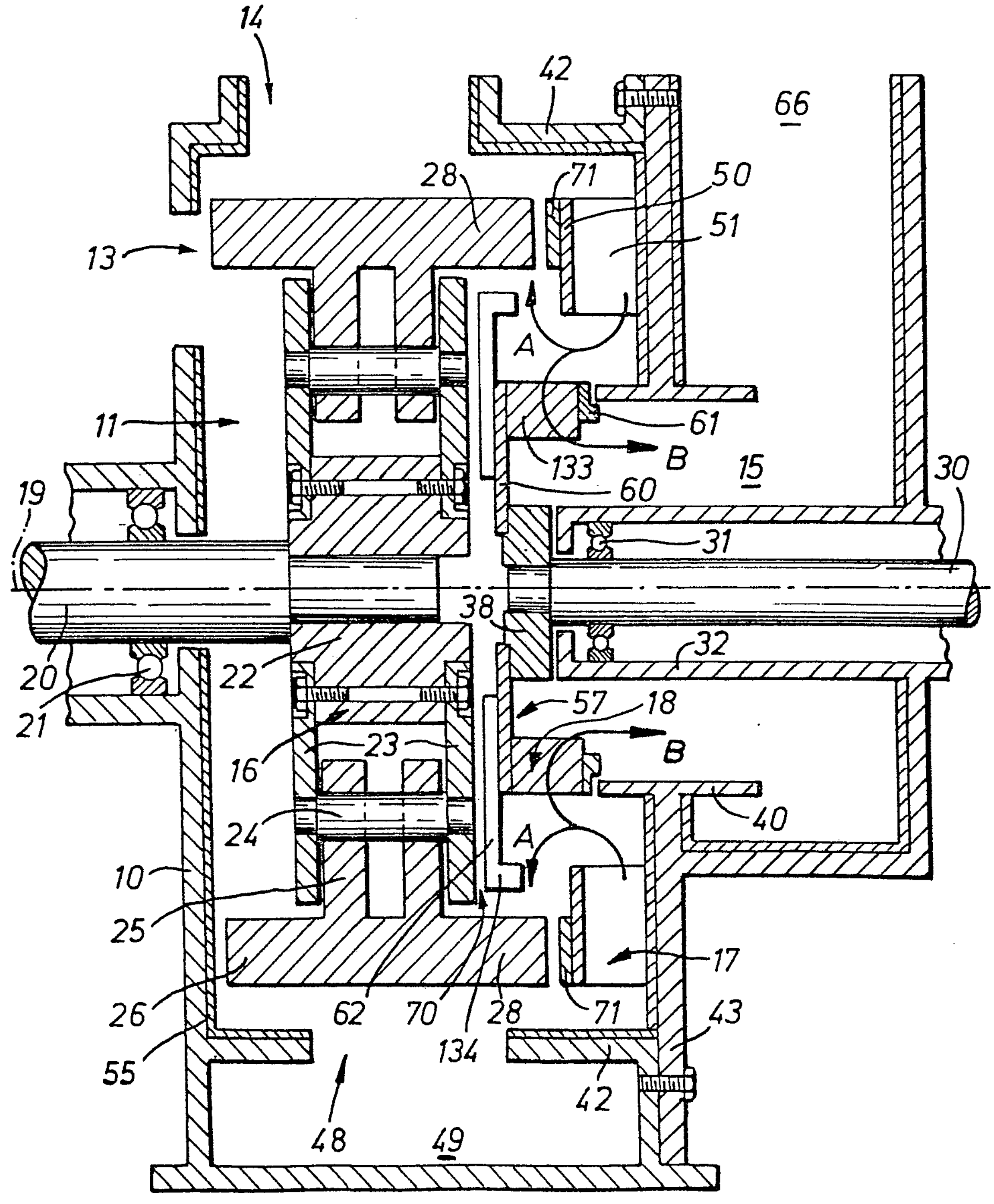
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FIG. 7.

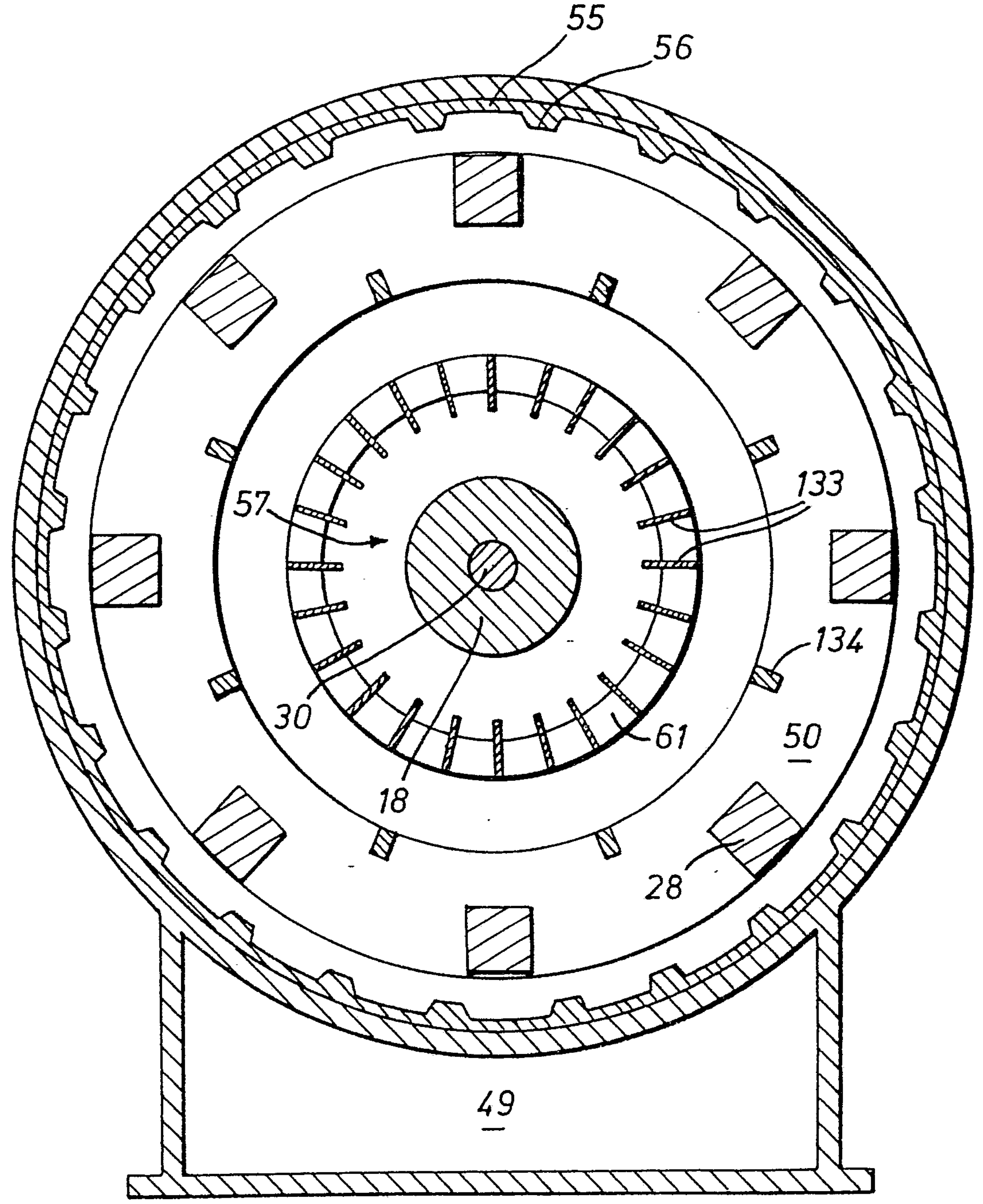

FIG. 8.